

ON THE CRYSTALLOGRAPHY OF ANATASE CRYSTALS FROM
THE AURIFEROUS CONGLOMERATE OF THE WIT-
WATERSRAND.

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Dr. Robert B. Young, in a paper on "Metasomatism in Banket,"* when describing a certain altered rock in the Rose Deep Gold Mine, South Reef Leader, says that the rock is composed mainly of chlorite and sericite, but when it is washed there remains a heavy concentrate composed of pyrite, anatase (octahedrite), zircon, chromite, and gold.

Dr. Robert B. Young's description of the anatase crystals is as follows:—

*"The anatase does not occur as pseudomorphs after rutile, but as well-formed tetragonal crystals, which may be roughly described as acute bipyramids. They vary in length from about $\frac{3}{4}$ mm. to about one-sixth of that, the average lying midway between these extremes. By reflected light they are a deep indigo-blue in colour. The lustre is adamantine. In transmitted light they are most of them blue. In polarised light they are pleochroic in different shades of blue and yellow. Very many of the crystals are partially or wholly opaque."**

A quantity of this anatase was obtained from Dr. Young and carefully examined by means of the Czapski Theodolite Goniometer (in its improved form),† fitted with a Schrauf signal.

A preliminary general examination of the best crystals showed that the most prominent faces are those which together constitute the tetragonal bipyramid of the first order—probably (111). These faces present brilliantly reflecting surfaces. Next to these the most obvious form is the tetragonal bipyramid of the second order—probably (101)—capping the

* Young, *Trans. Geol. Soc. S.A.*, vol. xvii., p. 32.

† Tutton, "Crystallography and Practical Crystal Measurement," p. 465, fig. 431. London, 1911.

former. These two forms are easily visible to the unaided eye. When viewed under the lower power of the microscope, the crystals show in addition several other forms. These are, apparently :

1. The basal pinacoid.
2. Faces presumably belonging to four other tetragonal bipyramids of the first order.

Qualitative chemical tests fully established the presence of titanium.

THE PROMINENT TETRAGONAL BIPYRAMID OF THE FIRST ORDER.

The extraordinary brilliancy of these faces allows of their angles being measured with very great accuracy, the Schrauf signal obtained in every case being "excellent."

Determination of Angles between the face normals of the faces of the First-Order Pyramid.

$$111 \wedge \bar{1}\bar{1}1 = 136^\circ 36'$$

$$111 \wedge \bar{1}11 = 136^\circ 36'$$

The above results were obtained as averages of several readings on four different individual crystals, and none of the readings varied from the average by a greater amount than $\pm 1'$.

From the above values we derive

$$001 \wedge 111 = 68^\circ 18'.$$

and an application of the usual formula

$$\tan (001 \wedge 111) \cdot \frac{1}{2}\sqrt{2} = c$$

leads to the following value for the axial ratio

$$a:c = 1:1.7769,$$

while the standard value given by Goldschmidt in his "Winkeltabellen" for anatase is 1:1.7771.

THE TETRAGONAL BIPYRAMID OF THE SECOND ORDER.

The faces which constitute this form give fairly good signals.

Determination of Angles between face normals of Second-Order Pyramid.

$$e^I \wedge e^{III} = 120^\circ 32'.$$

$$e^{II} \wedge e^{IV} = 120^\circ 34'.$$

These results again represent averages of several readings obtained on four different individual crystals. The greatest divergence from the average ($120^{\circ} 33'$) obtained in any one reading was $\pm 7'$.

From this angular result and the axial ratio we derive for this Second-Order Pyramid the symbol (101).

FORMS OTHER THAN (111) AND (101).

The minuteness of the remaining faces mentioned above necessitates one's being satisfied with measurements of angles taken with the telescope focused on the crystal face to observe the flash of the reflection from the faces, too minute to give efficient Schrauf signals. Consequently for each face the mid-position between angle readings taken (1) just when the flash begins to be observed, and (2) just when it is about to disappear, must be taken as indicative of the position of the face-normal. The accuracy of these angles is therefore of a lower order than in the previous cases, but several measurements were taken and the error of each of these averages is probably well within the limits of $\pm 1^{\circ}$.

The position angles of the forms obtained in this way, together with the two forms already described, were observed in terms of Goldschmidt's angle co-ordinates,* ϕ , ρ , and for purposes of comparison and identification of these forms Goldschmidt's standard values of ϕ , ρ , in each case together with the corresponding Miller Symbols and Dana face letters, are given in parallel column.

Face Letter.	Miller Symbol.	Goldschmidt's Standard Values.		Values obtained on Johannesburg Crystals.		Differences from Standard.
		ϕ	ρ	ϕ	ρ	
<i>p</i>	111	45°	$68^{\circ} 18'$	45°	$68^{\circ} 18'$	—
<i>e</i>	101	0°	$60^{\circ} 38'$	0°	$60^{\circ} 17''$	$0^{\circ} 21'$
<i>c</i>	001	—	$0^{\circ} 0'$	—	$0^{\circ} 0''$	—
μ	1.1.14	45°	$10^{\circ} 10'$	45°	$9^{\circ} 50''$	$0^{\circ} 20'$
<i>v</i>	117	45°	$19^{\circ} 44'$	45°	$19^{\circ} 40''$	$0^{\circ} 4'$
$\hat{e}$	331	45°	$82^{\circ} 26'$	45°	$82^{\circ} 47''$	$0^{\circ} 21'$
<i>x</i>	5.5.11	45°	$48^{\circ} 48'$	45°	$49^{\circ} 8''$	$0^{\circ} 20'$
<i>q</i>	021	0°	$74^{\circ} 17'$	0°	$74^{\circ} 2''$	$0^{\circ} 15'$

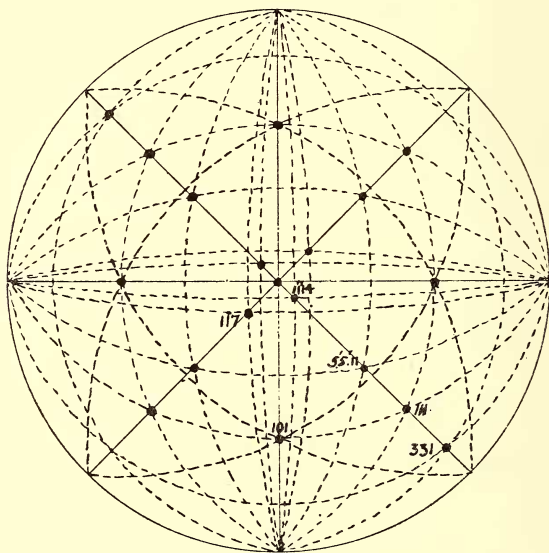
The form *q* was observed on only one of the crystals examined, while the other forms were observed on all four crystals.

* Goldschmidt, "Kristallographische Winkeltabellen," pp. 3, 39. Berlin, 1897.

In the foregoing work attention was confined to observation of faces on the upper half of the crystal in each case.

All four upper faces of (111) were observed		} On each of the four crystals examined.
" " (101)	"	
" " (5.5.11)	"	
Only two upper faces of (331)	"	
" " (1.1.14)	"	
" " (117)	"	

The crystal on which (021) was recognized showed only two faces of the form.



The precise position of each face seen on all four crystals is indicated on the accompanying stereographic projection.

It will be observed that the distribution of these faces suggests a

suspicion that anatase may not after all have the tetragonal holohedral symmetry of Class 15 hitherto assigned to it.*

An extended examination of a larger number of crystals is in progress with a view to confirming or disproving this suggestion.

The foregoing work was carried out in the Mineralogical Department of the South African College, Cape Town, under the general supervision of Dr. Andrew Young.

* Tutton, "Crystallography and Practical Crystal Measurement," p. 212. London, 1911.